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(72) Inventor: **Rose, William M. Warren**
Massachusetts 01585 (US)

(74) Representative: **Leckey, David Herbert Frank B. Dehn & Co.**
St Bride's House
10 Salisbury Square
London
EC4Y 8JD (GB)

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(71) Applicant: **United Technologies Corporation**
Hartford, CT 06101 (US)

(54) **Method of restoring an airfoil blade**

(57) A method of repairing an airfoil blade (10) involves the steps of providing an airfoil blade (10) have a leading edge (18), a trailing edge (22), a tip (26) and a base (30). A length (L) of the airfoil blade (10) is defined by the tip (26) and the base (30) and a width (W) of the airfoil blade (10) is defined by the leading edge (18) and the trailing edge (22). A weld (34) is made along a first direction (A) of the length (L) of the airfoil blade (10) and

then made in a second direction (B) along the width (W) of the airfoil blade (10) to form a first weld layer (34). The first weld layer (34) has a first portion (38) extending across the length (L) of the airfoil blade (10) and a second portion (42) extending across its width (W). A second weld layer (54) is welded onto the first layer (34) such that an end wall (58) of the second weld layer (62) abuts the second portion (42) of the first weld layer (54).

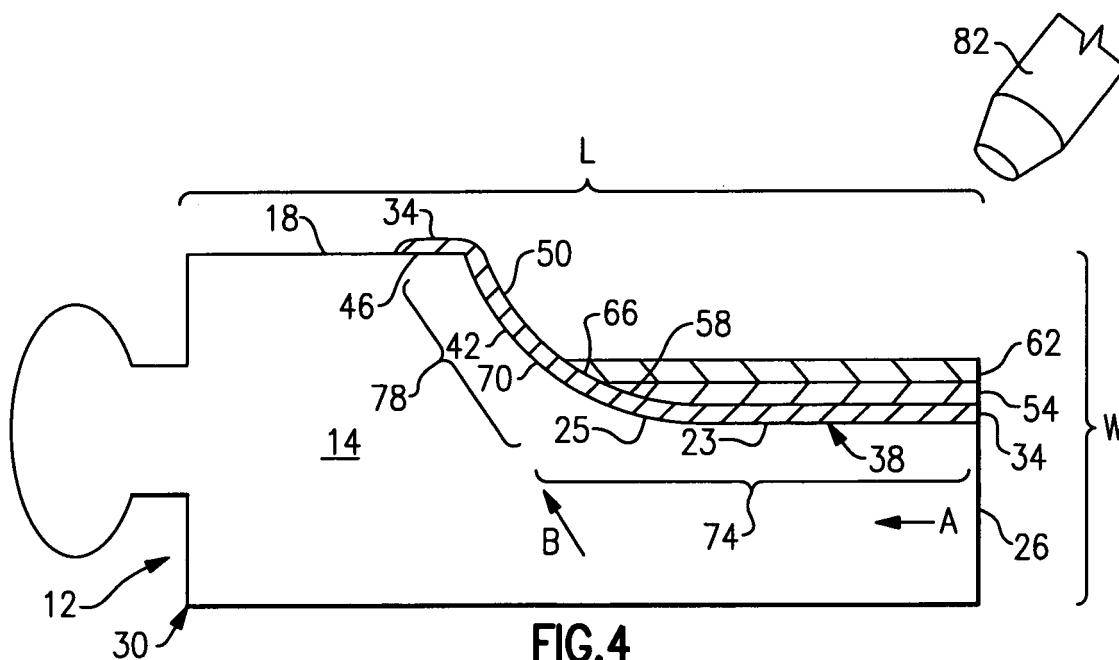


FIG. 4

Description**BACKGROUND OF THE INVENTION**

[0001] This invention relates to a method for restoring an airfoil blade, such as for a gas turbine engine.

[0002] An airfoil blade for a gas turbine engine generally experiences wear during normal engine operation. To avoid buying a new airfoil blade, it may be desirable to restore the worn airfoil blade.

[0003] With reference to Figure 1, there is shown a prior art technique for restoring airfoil blade 10. Airfoil blade 10 has leading edge 18 spaced from trailing edge 22 and tip 26 spaced from base 30. Length L is defined between tip 26 and base 30 while width W is defined between leading edge 18 and trailing edge 22. Generally, restoration of airfoil blade 10 involves machining away thin and worn surfaces from airfoil blade body 14 to form ledge 23 with curve 25, which extends from tip 26 to one of leading edge 18 or trailing edge 22. Substantially parallel weld layers 20 are then deposited on ledge 23 by welding, such as by laser powder fusion or plasma arc welding, in the direction of arrow A from tip 26 along length L of airfoil blade 10 to curve 25. Each weld layer 20 starts at tip 26 and ends at points 21 of curve 25. However, because welding of weld layers 20 is stopped at points 21 of curve 25, air foil body 14 may melt or burn in the areas around points 21 due to excess heat from welding. Consequently, these areas of airfoil blade 10 may require rework, such as additional welding and machining of these areas, which is very time-consuming.

[0004] A need therefore exists for an improved welding technique that eliminates the welding imperfection caused by localized melting at the point of contact of the weld layer with the airfoil blade body.

SUMMARY OF THE INVENTION

[0005] A disclosed preferred method of repairing an airfoil blade involves the steps of providing an airfoil blade have a leading edge, a trailing edge, a tip and a base. A length of the airfoil blade is defined by the tip and the base and a width of the airfoil blade is defined by the leading edge and the trailing edge. A weld is made along a first direction of the length of the airfoil blade and then made in a second direction along the width of the airfoil blade to form a first weld layer. The first weld layer has a first portion extending across the length of the airfoil blade and a second portion extending across its width. A second weld layer is welded onto the first layer such that an end wall of the second weld layer abuts the second portion of the first weld layer.

[0006] The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS**[0007]**

Figure 1 illustrates a prior art welding technique for restoring an airfoil blade.

Figure 2 illustrates an exemplary welding method for restoring an airfoil blade.

Figure 3 illustrates part of the process of the inventive technique of Figure 2.

Figure 4 illustrates another step in the process of the inventive welding technique, showing a formation of a first welding layer and additional layers atop the first welding layer.

Figure 5 illustrates a cross-sectional view of the airfoil blade of Figure 4, showing a thickness of the first weld layer greater than a thickness of a wall of the airfoil blade.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0008] With reference to Figure 2, the exemplary method for welding facilitates avoiding the foregoing problems of the prior art by creating first weld layer 34 that extends substantially across ledge 23 and curve 25. In other words, first weld layer 34 extends substantially across an entire length L and width W of exemplary airfoil blade 12. Weld layers 20 are then deposited on first weld layer 34 such that each weld layer 20 terminates on first weld layer 34 rather than airfoil blade 12. As a result, first weld layer 34 acts as a heat buffer to absorb excess heat along curve 25 from subsequent welds as will be explained.

[0009] With reference to Figure 3, there is shown airfoil blade 12 including airfoil blade body 14 with worn portion 35 designated by dashed lines. Through machining, worn portion 35 is removed from airfoil blade 12 to create ledge 23, including curve 25, atop which weld layers will be provided to restore length L and width W of airfoil blade 12.

[0010] With reference to Figure 4, first weld layer 34 is created by welding on ledge 23 from tip 26 towards base 30 by moving weld gun 82 in the direction of arrow A along length L of airfoil blade 12. At curve 25, welding gun 82 is then moved in the transverse direction of arrow B to follow curve 25 of ledge 23 across width W of airfoil blade 12. Welding gun 82 continues welding across an edge, such as leading edge 18, of airfoil blade 12. Welding gun 82 remains active to weld in a single pass first weld layer 34 from tip 26 across leading edge 18. Although weld formation is described with reference to moving weld gun 82 with respect to airfoil blade 12, it should be appreciated by one of ordinary skill in the art that airfoil blade 12 may be moved with respect to welding gun 82 while achieving similar results.

[0011] First weld layer 34 includes first portion 38 and second portion 42 that together form a curve. First portion 38 extends generally along length L of airfoil blade 12

and restores portion 74 of length L of airfoil blade 12. Second portion 42 extends generally along width W of airfoil blade 12 and restores portion of width 78 of airfoil blade 12. First weld layer 34 has first surface 46 in contact with airfoil blade body 14 and second surface 50 spaced away from first surface 46.

[0012] Figure 5 shows a cross-sectional view of airfoil blade 12 including first weld layer 34, as shown from the direction of arrow A of Figure 4. Airfoil blade 12 includes suction side wall 86 and pressure side wall 90 having wall thickness 98. First weld layer 34 is formed having first weld layer thickness 94, which is greater than wall thickness 98 of suction sidewall 86 at location 102. As a result, first weld layer 34 is thick enough to absorb excess heat from welding gun 82 to facilitate avoiding localized melting or damage of airfoil blade 12.

[0013] Following formation of first weld layer 34, weld gun 82 is brought back to tip 26 of airfoil blade 12. Weld gun 12 then welds in the direction of arrow A to create second weld layer 54 so that end wall 58 of second weld layer 54 abuts second surface 50 of first weld layer 34. By terminating second weld layer 54 at first weld layer 34 instead of airfoil blade 12, excess heat may be absorbed by first weld layer 34 so as to facilitate avoiding blade damage. A third weld layer 62 is also created by welding in the same manner and same direction as the second weld layer 54. Third weld layer 62 is formed so that end wall 66 of third weld layer 62 abuts second surface 50 of first weld layer 34. Welding gun 82 continues to create weld layers like second weld layer 54 and third weld layer 62 up to leading edge 18 as shown in Figure 2, with each weld layer starting at tip 26 and terminating at second surface 50 of first weld layer 34. Following this welding process, airfoil blade 12 may then be machined so that airfoil blade 12 conforms to its original dimensions.

[0014] The foregoing description shall be interpreted as illustrative and not in any limiting sense. A worker of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. For that reason, the follow claims should be studied to determine the true scope and content of this invention.

Claims

1. A method of repairing an airfoil blade (10), comprising the steps of:

(A) providing the airfoil blade (10) having a leading edge (18), a trailing edge (22), a tip (26) and a base (30), a length (L) of the airfoil blade (10) defined by the tip (26) and the base (30) and a width (W) of the airfoil blade (10) defined by the leading edge (18) and the trailing edge (22);
 (B) welding in a first direction (A) along the length (L) of the airfoil blade (10) and welding in a second direction (B) transverse to the first direction (A) and along the width (W) of the airfoil blade

(10) to form a first weld layer (34) having a first portion (38) extending across the length (L) and a second portion (42) extending across the width (W) to restore at least a portion (74) of the length (L) and a portion (78) of the width (W) of the airfoil blade (10); and

(C) welding a second weld layer (54) on to the first weld layer (34) such that an end wall (58) of the second weld layer (54) abuts the second portion (42) of the first weld layer (34).

2. The method of Claim 1 including the step of:

(D) welding a third weld layer (62) on to the second weld layer (54) such that an end wall (66) of the third weld layer (62) abuts the second portion (42) of the first weld layer (34).

3. The method of Claim 1 or 2 wherein the first weld layer (34) has a first surface and a second surface, the first surface in contact with the airfoil blade (10) and the second surface in contact with the end wall (58) of the second weld layer (54).

4. A method of repairing an airfoil blade (10), comprising the steps of:

(A) providing the airfoil blade (10) having a leading edge (18), a trailing edge (22), a tip and a base (30), a length (L) of the airfoil blade (10) defined by the tip (26) and the base (30) and a width (W) of the airfoil blade (10) defined by the leading edge (18) and the trailing edge (22);

(B) welding in a first direction (A) along the length (L) of the airfoil blade (10) and welding in a second direction (B) along the width (W) of the airfoil blade (10) to form a first weld layer (34) having a first portion (38) extending across the length (L) and a second portion (42) extending across the width (W) to restore at least a portion (74) of the length (L) and a portion (78) of the width (W) of the airfoil blade (10) wherein the first weld layer (34) has a first surface in contact with the airfoil blade (10) and a second surface;

(C) welding a second weld layer (54) on to the first weld layer (34) such that an end wall (58) of the second weld layer (54) abuts the second portion (42) of the first weld layer (34) on the second surface of the first weld layer (34); and
 (D) welding a third weld layer (62) on to the second weld layer (54) such that an end wall (66) of the third weld layer (62) abuts the second portion (42) of the first weld layer (34) on the second surface of the first weld layer (34).

5. The method of any preceding Claim wherein the second portion (42) extends to one of the leading edge (18) and the trailing edge (22) of the airfoil blade (10).

6. The method of Claim 5 wherein the first weld layer (34) is formed across one of the leading edge (18) and the trailing edge (22) along the length (L) of airfoil blade (10). 5
7. The method of any preceding Claim wherein the first weld layer (34) is formed in a single pass.
8. The method of any preceding Claim wherein the first portion (38) and the second portion (42) of the first weld layer (34) form a curve. 10
9. The method of any preceding Claim wherein the airfoil blade (10) has a suction side wall (86) and a pressure side wall (90), wherein the first weld layer (34) is formed having a first weld layer thickness (94) greater than a wall thickness (86) of one of the suction side wall (86) and the pressure side wall (90) at a location of the airfoil blade (10) neighboring the first weld layer (34). 15 20
10. The method of any preceding Claim including the step of:
- removing a portion of the airfoil blade (10) prior to step (B) to accommodate the first weld layer (34). 25
11. The method of any preceding Claim including the step of: 30
- machining a portion of at least one of the first weld layer (34) and the second weld layer (54).
12. An airfoil blade (10), comprising: 35
- an airfoil body having a leading edge (18), a trailing edge (22), a tip (26) and a base (30), a length (L) of said airfoil body (10) defined by said tip (26) and said base (30) and a width (W) of said airfoil body (10) defined by said leading edge (18) and said trailing edge (22); 40
- a first weld layer (34) having a first portion (38) extending across said length (L) and a second portion (42) extending across said width (W) restoring at least a portion (74) of said length (L) and a portion (78) of said width (W) of said airfoil blade (10) wherein said first weld layer (34) has a first surface in contact with said airfoil blade (10) and a second surface spaced from said first surface; and 45 50
- a second weld layer (54) disposed on said first weld layer (34) such that an end wall (58) of said second weld layer (54) abuts said second portion (42) of said first weld layer (34) on said second surface of said first weld layer (34). 55
13. An airfoil blade of Claim 12 including a third weld layer (62) disposed on to said second weld layer (54) such that an end wall (66) of said third weld layer (62) abuts said second portion (42) of said first weld layer (34) on said second surface of said first weld layer (34).
14. The airfoil blade of Claim 12 or 13 wherein said first portion (38) and said second portion (42) of said first weld layer (34) forms a curve.

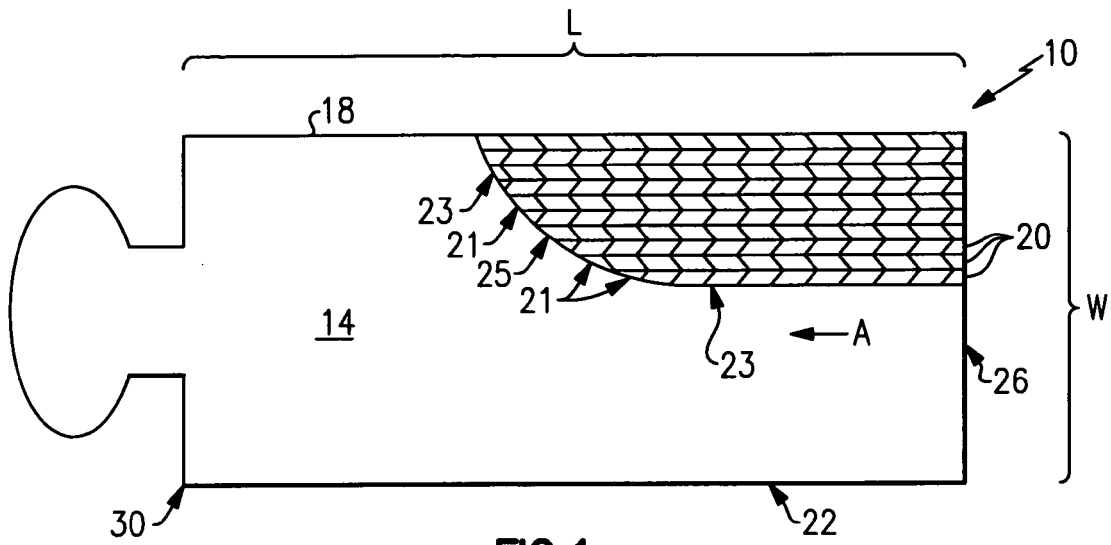


FIG.1
Prior Art

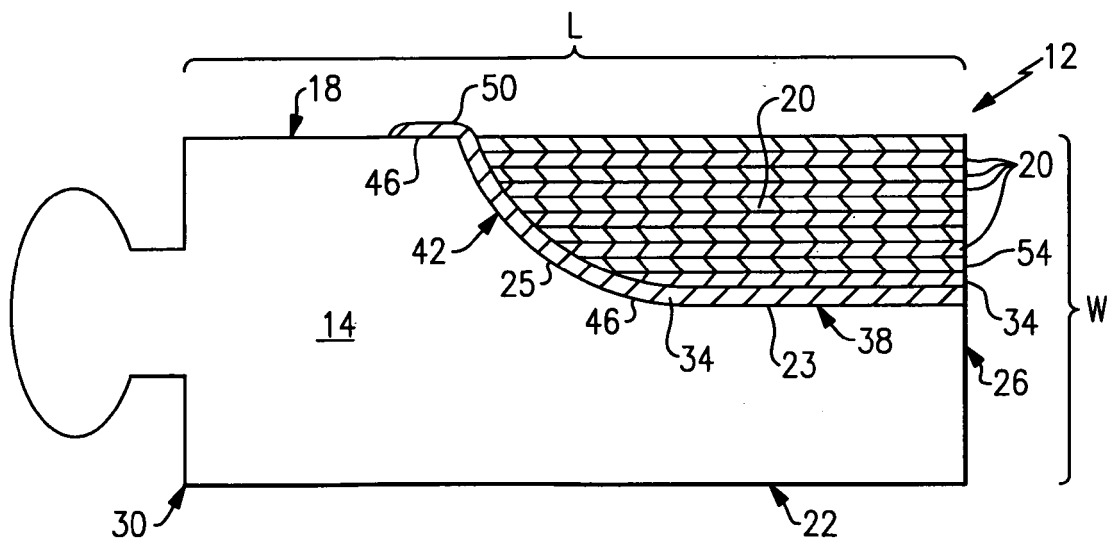


FIG.2

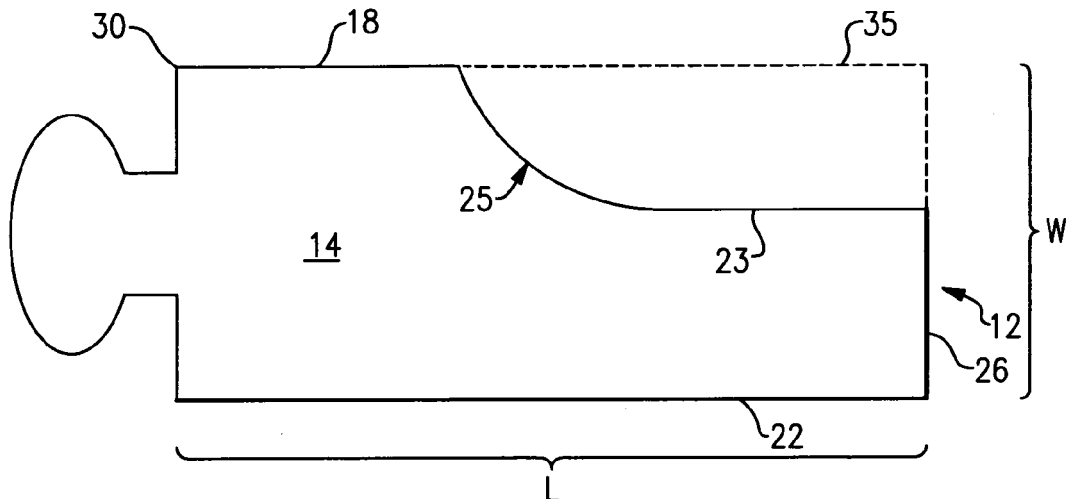


FIG. 3

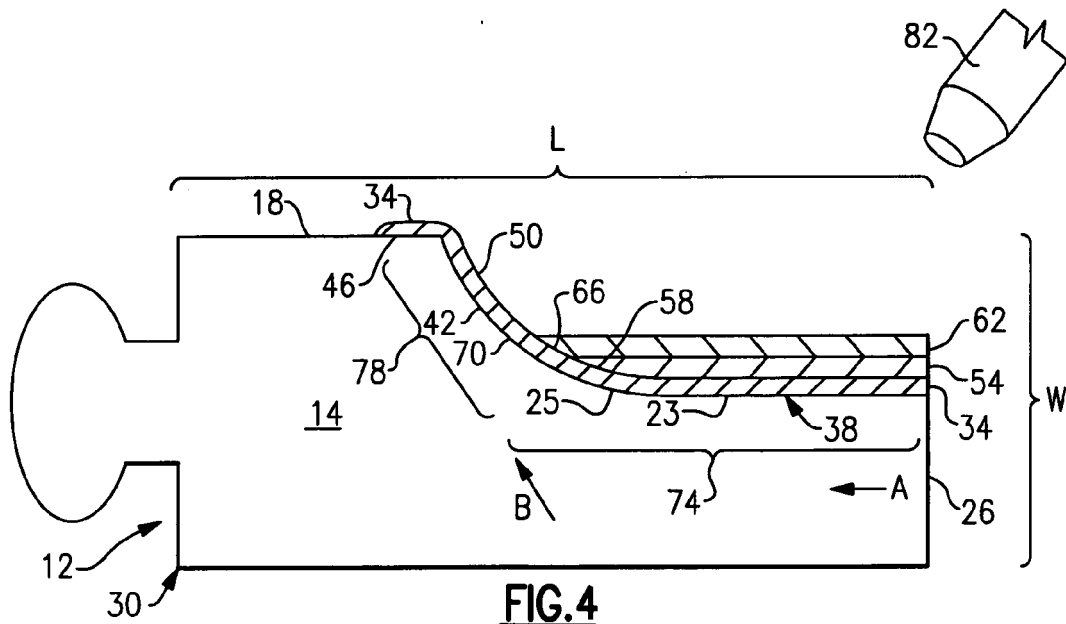


FIG. 4

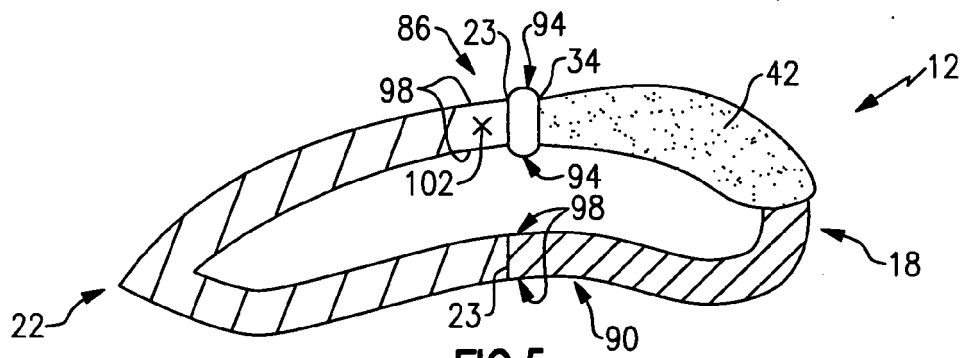


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 09 25 0652

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 April 2009	Examiner Stocker, Christian
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

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EPO FORM 1503 03/82 (P04C01)



EUROPEAN SEARCH REPORT

Application Number
EP 09 25 0652

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 April 2009	Examiner Stocker, Christian
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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The members are as contained in the European Patent Office EDP file on
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